

Energy Crisis & CPEC Projects: A Step towards Sustainable Pakistan

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Abstract: Pakistan suffers from a severe energy crisis that has been a long-standing issue and has sharply impacted the economic and social development of the country. Thus, the China-Pakistan Economic Corridor (CPEC) evolves as a strategic project instrumental to meet the power needs of Pakistan and spur overall growth. Therefore, this paper aims to provide a synthesis of the literature on the role and efficiency of CPEC in tackling energy shortages and the consequent social and economic ramifications. Therefore, the analytical analysis shows that CPEC has helped to reduce energy unavailability and load shedding issues with load shedding reduced by 70 percent in major cities, as indicated by NEPRA. For instance, by looking at the Sahiwal Coal Power Plant case, the impact of increasing generation capacity to overcome energy shortages can be clearly seen. In addition, energy projects under CPEC have provided more than 303,000 direct employment which in turn has a positive impact on the economy and has led to social development of the region. There have been major advancements in health and education facilities due to improved energy access. Hospitals, for instance, recorded reduced cases of power cuts while students could study in a conducive environment. These findings characterize the significance of CPEC role in overcoming Pakistan's energy problems and promoting socio-economic advancement.

Key Words: Pakistan, Energy Crisis, CPEC, Renewable Energy, Sustainable Development

Introduction

For quite a few years now, Pakistan has been experiencing a significant energy emergency, which has now turned into a colossal impediment to the turn of events and development of Pakistan's economy. As the number of inhabitants in Pakistan keeps on increasing at an expanding rate, alongside quickly creating residential areas, it has prompted an overpowering weight on energy assets. Interest in energy assets has expanded certainly, however, the absence of supply because of lacking domestic energy results, and shortcomings in the ongoing energy framework has prompted an immense crisis that is turning out to be more extreme as time passes. This crisis brings about a continuous deficit of gas and electricity, which influences not exclusively Pakistan's industry but also the residential areas, prompting successive blackouts, and load shedding of gas. (Javed et al., 2016)

The China-Pakistan Economic Corridor (CPEC), is one of the pioneering developments that has arisen as a significant advancement drive to satisfy Pakistan's energy emergency requests and thus advance monetary and exchange relations between the two nations. CPEC, a highlight of China's Belt and Road Initiative (BRI), is a move toward financial regionalization inside the structure of globalization. Perceiving the need for energy accessibility and the requirement for a monetary framework, the CPEC intends to develop an organization of tasks including power plants, sustainable power drives, and transmission lines. These undertakings won't just provide assistance to China and

Pakistan but also help adjoining nations like Iran, Afghanistan, India, and the Central Asian Republics by advancing inclusivity and network. CPEC is likewise accepted to act as a course for information, social, and scholarly exchange among the two nations further reinforcing the ties between the two. (Hassan, 2020)

Perusing the literature regarding the matter is significant to understanding the job that CPEC will play in easing Pakistan's energy issue. The reason for this research is to look at scholarly articles, research papers, and studies that shed light on Pakistan's energy problem and consider how CPEC could assist with tending to it. Through a basic examination of the group of material currently in presence, this study plans to pinpoint significant disclosures, examples, and information gaps to propel an exhaustive cognizance of the complex elements relating to Pakistani framework development and energy inconveniences.

A deliberate system will be utilized to play out this writing study, which will incorporate thorough research and examination of government distributions, peer-reviewed papers, and other relevant sources. The selected sources will go through an extensive assessment to separate important information about the beginnings and impacts of Pakistan's energy emergency as well as the potential impacts of the China-Pakistan Economic Corridor (CPEC) on the country's energy climate. This research endeavors to explain the various parts of Pakistan's energy circumstance and proposition bits of knowledge into how CPEC can help by consolidating and assessing the accessible data. The research's decisions won't just add

to the collection of information yet in addition have true repercussions for everybody in question in deciding Pakistan's energy future — policymakers, energy subject matter experts, and different authorities.

Literature Review

Historical Context of Pakistan's Energy Sector

Post-Independence Period and Early Developments

The foundation of a steady energy framework has been quite difficult for Pakistan since it acquired freedom in 1947. At first, the nation depended on its hydropower specifically through dam activities, for example, Mangla and Tarbela that were essential for the 1960 Indus Basin Development Project. These undertakings are fundamental for the administration of water assets and energy supplies for a quickly developing populace and industrial sector. (Khatri et al., 2022) (*Pakistan's Energy Crisis | The National Bureau of Asian Research (NBR)*, n.d.).

Shift to Fossil Fuels and Energy Policies

Because of expanding industrialization and urbanization, Pakistan started to enhance its energy blend during the 1970s. Petroleum derivatives, specifically natural gas and oil, were the focal point of consideration. During this period, the improvement of public oil fields and infrastructure to transport raw petroleum was likewise completed. In any case, because of the critical effect of worldwide oil cost shocks on Pakistan's economy and energy security during the 1970s and 1980s, this progress has confronted difficulties. (Hameed T, 2015)

With the introduction of strategies to draw in private investments, the 1980s and 1990s denoted a significant period in Pakistan's energy area. The 1994 Energy Policy, which urged the private sector to take part in energy production, was a milestone drive pointed toward tending to constant power deficiencies. This approach has prompted the establishment of several independent power producers, which have assisted with relieving a portion of the immediate energy crisis, however have likewise introduced issues related to cost and tariff disputes. (Khatri et al., 2022)

The Era of Energy Crises and Policy Reforms

In the early 2000s, Pakistan's energy sector was faced with successive power deficiencies, rising circular debt, and developing dependence on imported petroleum products. The emergency has been exasperated by the absence of a smart course of action and interest in the energy framework over the long term. Accordingly, the government has taken several initiatives to expand the share of renewables in its energy blend, like the 2006 Renewable Energy Strategy. In any case, because of regulatory failures and deficient approach structures, execution has been falling behind. (Khatri et al., 2022)

Recent Developments and CPEC Initiatives

The China-Pakistan Economic Corridor (CPEC) has become a huge driver of energy progression in Pakistan in recent years. To address the continuous energy lack and modernize its system, CPEC integrates different energy endeavors, for instance, coal-ended power plants or wind farms. These activities can possibly change Pakistan's energy framework, by empowering it to meet an earnest requirement for capacity and enhancing its energy blend. (Ahmed et al., 2019)

Current Energy Mix

Breakdown of Energy Sources (Thermal, Hydro, Nuclear, Renewable)

Pakistan's energy blend has been dominated by thermal sources for several years now, along with this hydropower, nuclear power, and recently flourishing renewable energies also contribute considerably to the energy mix. The following recent reports show the breakdown of energy supply in Pakistan:

1. **Thermal Energy:** Most of Pakistan's energy creation is taken up by heat power, including fuel from oil, gas, and coal. Specifically, the largest sources of energy are natural gas, followed by oil and coal. Natural gas represented 29% of the total essential energy supply in 2021, followed by oil adding up to 19.9%, and coal representing around 13.7%. (*Pakistan - Countries & Regions*, n.d.)
2. **Hydropower:** In Pakistan, hydropower represents around 9.1% of the national energy blend and is the main source of sustainable power. The landscape of the country, with numerous rivers and appropriate catchment regions for dams, upholds this impressive hydropower limit. In this area, major hydropower projects including the Tarbela and Mangla dams assume a key role. (*Share of Primary Energy Consumption from Hydroelectric Power*, n.d.)
3. **Nuclear Energy:** Roughly, 5.57% of the total energy supply of Pakistan comes from nuclear energy, a small but crucial share. The Government has taken the initiative to expand and guarantee a more stable energy blend with the advancement of nuclear power plants, for example, the Chashma Nuclear Power Station and Karachi Nuclear Power Plant. (Ritchie et al., 2024)
4. **Renewable Energy:** Renewable resources such as wind, solar, and biomass's share of energy have been steadily increasing over the course of time. Presently, excluding hydropower, renewables account for about 1.3% of the total energy mix. (Khatri et al., 2022) To further

increase the share of renewables in the coming years, the government has taken several initiatives, moreover, foreign investments such as CPEC, will play a crucial role in the utilization of these resources.

Role of Imported Energy

Specifically, the import of oil and liquefied natural gas assume a key part of Pakistan's energy framework. Specifically, in 2021 the country's crude oil imports added up to 68.1%, showing an increment of 26% in the oil imports pattern starting around 2000. (*Pakistan - Countries & Regions*, n.d.) Pakistan is defenseless against worldwide market fluctuations because of its dependence on foreign oil, adding to the country's energy vulnerability and economic issues. (Hussain & Hassan, 2019)

Pakistan has additionally expanded its LNG imports throughout the course of recent years, to overcome the domestic gas deficiencies. In 2020, Pakistan's LNG imports added up to 7.4 million tons, and the demand for LNG is supposed to increase progressively throughout the following ten years. (*Pakistan's Dependence on Imported LNG Exacerbates Energy Insecurity and Financial Instability*, n.d.) To ensure a constant supply, the Government has been effectively seeking long-term LNG supply agreements and investment in liquefaction infrastructure like regasification terminals. (Zakir et al., 2020)

Challenges Facing Pakistan's Energy Sector

Energy Deficit and Load Shedding

Extent of Energy Shortages

Pakistan has been suffering from a lack of energy in the last decade. The energy deficit remained at a frequency of between 5,000 and 8,000 MW. (Xin et al., 2022) Consequently, the gap resulted in substantial reductions in load which have had a major impact on domestic and industry consumers. There is a constant oversupply of power and this has resulted in the total lack of energy supply, as reported by the NCA. ("Pakistan's Energy Sector," n.d.)

Lack of generation capacity, aging infrastructure, inadequate policy implementations, rapid industrialization, major reliance on non-renewable fuels, and inefficiencies in the distribution network are among the main reasons for these shortages. (Akbar, Riaz, et al., 2021) This issue is exacerbated by the reliance on imported fuel and the monetary challenges of power organizations, which makes it hard to conquer supply deficiencies. To fulfill developing needs, Pakistan's energy infrastructure needs modernization and extension. (Xin et al., 2022)

Impact on Households and Industries

Households are very affected by the energy shortage. Life is interrupted from basic lighting and cooling to

more pressing needs such as water supply or food storage, because of the frequent reduction in load. In hot summer months, the lack of electricity may cause severe inconvenience and health problems in particular among vulnerable groups.

On the other hand, for industry, there is a much higher risk. In view of the reliance on standby power plants and productivity losses, a lack of energy results in reduced industry output and increased operating costs. The manufacturing sector, which is dependent on a continuous power supply, encounters critical downtimes, prompting monetary losses and diminished competitiveness in the worldwide market. (Grainger & Zhang, 2019)

There are significant consequences for the economy as a result of load shedding. Billions of dollars are lost every year as a result of blackouts, leading to huge economic losses. (Aziz et al., 2010) This loss is not only due to reduced industrial productivity but also to the cost of operating alternative energy sources and their resulting environmental impact through increased use of diesel power stations. (Xin et al., 2022)

For Pakistan to meet its energy shortage, it is important to change all parts of its energy strategy, i.e. investment in infrastructure, adequate funding, and shift from petroleum products towards greener energies. (Wakeel et al., 2016) These measures are needed in order to guarantee a secure supply of energy, which is capable of stimulating both demand for housing and industrial growth.

Infrastructure and Transmission Issues

Aging Infrastructure

Pakistan's energy infrastructure is in a serious state of deterioration, with much of it built over the last decades. Inefficiencies and frequent breakdowns are a result of this aging infrastructure. A large part of Pakistan's power generation capacity is based on outdated and ineffective plants, which are consuming more fuel and producing less electricity than modern ones. This inefficiency is not just leading to an increase in operational costs, it also raises emissions and exacerbates problems with the environment. (Shakeel et al., 2016)

This situation is due to the lack of maintenance on power plants and transmission lines, as well as delays in their modernization. In order to meet the requirements for repairs and updates, the National Transmission and Distribution Company (NTDC) which has been entrusted with the management of the network in Pakistan is facing a significant challenge. Due to the lack of investment in new infrastructure and a slow pace of modernization, the network is at risk of periodic breakdowns and blackouts that affect everyday life and economic growth. (*Pakistan's*

Energy Crisis | The National Bureau of Asian Research (NBR), n.d.)

Transmission and Distribution Losses

Another critical problem in Pakistan's energy sector is the loss of transmission and distribution. This loss is caused by a combination of technical inefficiencies, theft, and inadequate infrastructure. (Admin, 2023) The T&D losses in Pakistan are among the highest in the world, ranging from 18% to 20% of the total electricity generated, according to recent analyses. (Ali et al., 2013) The loss of revenue is a significant burden on the power sector, which will reduce funds that could be invested in system improvement.

Old and inefficient transmission lines and equipment are primarily to blame for technical losses. There is an overload on many transmission lines and they are operating in excess of their intended capacity, leading to increased resistance and power losses. Moreover, there is a widespread and significant loss of T&D due to electricity theft including illegal connections as well as meter tampering. Efforts have been made to reduce theft and increase revenue collection, but there is still a need for more concerted action and stronger enforcement in order to make significant progress. ("Pakistan'S Energy Sector," n.d.)

Moreover, the weak transmission network means that it is not possible for new projects like the China-Pakistan Economic Corridor to be integrated effectively into the national grid. This bottleneck, which is impeding the potential benefits of these new projects and underlines the need for a comprehensive approach to energy infrastructure upgrading from generation to distribution, illustrates that there is an urgent need. (Ul-Haq et al., 2021)

The China-Pakistan Economic Corridor (CPEC)

Introduction to CPEC:

Objectives and Scope of CPEC

The CPEC is one of the most significant and largest routes of the BRI, which is a cross-continental project that targets to boost connectivity in the region and promote economic growth. CPEC has set out with the main goals of enhancing connectivity, economic cooperation, and integration as well as regional trade between China and Pakistan and other countries of the region including the Central Asian states and the Middle East. As some observers argue, it is planned to connect Gwadar Port in Pakistan with Kashgar in China's Xinjiang province and advance the developments in the region by launching trade channels (Hassan, 2020).

Key Sectors and Investments

A brief on the potential and ongoing projects of CPEC reveals that CPEC has the vision to cover almost all

sectors of transportation, energy production, infrastructure, and industrial setup. Such investments tend to go into construction projects of highways, railways, and pipelines to enhance transportation links. Moreover, these loans are also spent on the Energy Sector where Pakistan has a long-time crisis. Special industrial areas and specific economic zones are also being established to lure foreign investment and boost up industrial development. CPEC is a multi-billion dollar project and about \$62 billion is supposed to be invested in the project majorly in energy and infrastructural sectors (Akbar, Hassan, et al., 2021).

CPEC Energy Projects Overview

Major Energy Projects under CPEC

The CPEC was announced in 2013 and since then many projects have been planned and some have been completed this paper aims to focus on some of the major energy projects under the CPEC.

Most projects are considered energy projects intended to add additional generation capacity to Pakistan's energy-starved grid. These projects range across the various types of energy sources such as coal, water, solar, and wind types of energy sources. Major projects are the Sahiwal Coal-Fired Power Project, Karot Hydropower Project, Quaid-e-Azam Solar Power Project, and various wind power projects in Sindh & Baluchistan. These projects are expected to install thousands of megawatts to national grid density, minimizing the power deficits and strengthening energy security (Akbar, Hassan, et al., 2021)

Types of Energy Projects (Coal, Hydro, Solar, Wind)

- **Coal Projects:** Coal is one of the prominent resources utilized in energy projects under CPEC which contains coal-fired power plants. Sahiwal Coal Power Project is the largest of its kind with an installed capacity of 1320MW which is also known as one of the most important projects of CPEC. Other initiatives of coal projects include the Port Qasim and Hub coal-fired power plants. (Akbar, Hassan, et al., 2021)
- **Hydropower Projects:** Coming to Pakistan's river resources, hydropower plants which are the Karot and Suki Kinari hydropower plants can play the role of hydropower plants. besides playing its role in energy generation these projects also help in water management and irrigation systems. (Akbar, Hassan, et al., 2021)
- **Solar Projects:** Quaid-e-Azam Solar Park in Bahawalpur is one of the largest solar efforts that are part of the CPEC project. The project is planned to produce one GW of power, thus fostering the utilization of clean energy instead

of relying solely on traditional resources that include fossil energy (Akbar, Hassan, et al., 2021)

- **Wind Projects:** On-shore wind power schemes are being set up in the seaside districts of Sindh and Baluchistan.(Harijan et al., 2010) These projects, including the Jhimpir wind corridor, are expected to supply sustainable form and clean energy hence enhancing the renewable energy promise for Pakistan.(Rehman Tahir et al., 2018)

Impact of CPEC Energy Projects on Pakistan

Infrastructure Development and Modernization

New Power Plants and Capacity Additions

CPEC has resulted in the establishment of new power plants in addition to enhancements of existing power plants in terms of new generation capacity in Pakistan. The power plant and other similar projects such as the Sahiwal Coal Fire Power Plant as well as the Karot Hydropower project have also connected additional megawatts with the national energy grid to eliminate energy crises and promote industrialization. (Akbar, Hassan, et al., 2021)

Upgradation of Transmission Networks

CPEC also involves the improvement of the transmission line networks in Pakistan to improve the electricity distribution from new power plants. Upgrading the current grid constitutes the need for the increased load that is expected in the future together with the need to minimize the losses during transmission, in a bid to enhance the general efficiency of energy. (Akbar, Hassan, et al., 2021)

Diversification of Energy Mix

Introduction of Coal-Based Energy

Through CPEC, Pakistan has been able to shift from relying on oil and gas for energy needs and instead invest in coal-based energy plants. Coal might be a contentious option because of the negative effects on the environmental repercussions, yet it is steady and cheap to mine in order for the country to generate the energy it needs in the short run. (Hassan, 2020)

Expansion of Renewable Energy Projects

CPEC has also helped in electricity generation and extension of renewable energy resources like solar and wind farms. The construction of other renewable power plants such as that of the Quaid-e-Azam Solar Park in Punjab, and wind power plants in Sindh and Balochistan is evidence of the integration of sustainable energy in Pakistan's energy mix. (Akbar, Hassan, et al., 2021)

Economic and Social Impact

Job Creation and Economic Growth

CPEC Energy has provided ample employment opportunities in terms of jobs that are important for the economic prosperity of any country. These projects have directly generated employment for thousands of people in Pakistan and have contributed to the betterment of lives particularly in countries with such power plant facilities. (Akbar, Hassan, et al., 2021)

Social Benefits and Improved Energy Access

Facilitating the lives of people by increasing energy access through different projects, CPEC has had tremendous social impacts. Electrical energy when available in sufficient amounts and with high reliability improves the standards of living for citizens, aids in the functionality of education and healthcare sectors, and fosters several industrial and commercial initiatives. These developments are quite essential for the socio-economic rejuvenation of the communities strewn across Pakistan. (Hassan, 2020)

ANALYSIS & FINDINGS

Quantitative Analysis

The energy sector of Pakistan has taken a positive twist with the approval of CPEC which has led to the development of power projects in Pakistan. Before the launch of CPEC energy crisis was pretty much huge for Pakistan where the total installed power generation capacity in 2015 was only about 22000MW far below the present demand of the country. Generally, this capacity has enlarged tremendously after the initiation of CPEC projects. For example, the Sahiwal Coal-fired Power Project with 1320MW capacity, the Port Qasim Coal-fired power project with 1320MW, and the Quaid-e-Azam Solar Park with 1000MW capacity are significant accomplishments. (*Energy Projects Under CPEC | China-Pakistan Economic Corridor (CPEC) Secretariat Official Website*, n.d.) As per the official website of CPEC, it is evident that these projects have jointly contributed to an installed capacity of about 10,000 MW of electricity generation or more that are added to the national grid which certainly has enhanced the energy sector capacity of Pakistan (CGEP, 2019).

Qualitative Insights

In this regard, the enhancement of portfolio capacity as a result of the CPEC energy projects has not only been confined to capacity enhancement, but it has also enhanced the energy access and reliability for the population of Pakistan as well. Available data from the cross-sectional surveys and interviews with key stakeholders show that the instances of load shedding have been considerably reduced especially in urban areas. As an example, the industrial zones which were formerly affected by frequent load shedding for many

hours a day and night are now enjoying a relatively good and standard electricity-providing environment which in turn improves industrial productivity or growth. (CGEP, 2019; *Energy Projects Under CPEC | China-Pakistan Economic Corridor (CPEC) Secretariat Official Website*, n.d.)

Effectiveness of CPEC in Reducing Energy Deficits

Statistical Analysis

Energy crisis data helps highlight a vivid leaps and bounds reduction in energy unavailability and load-shedding incidents after CPEC. According to NEPRA, load-shedding was reduced to 70 percent in the major cities of Pakistan due to the implementation of CPEC projects (CGEP, 2019). They presume that CPEC has reduced the energy deficit due to the enhanced generation capacity and better distribution networks.

Case Studies

One vivid example is the Sahiwal Coal Power Plant; which was launched in 2017. Another facility of this plant is that it could supply 1320 MW to the grid which lessens the energy crisis in Punjab significantly. The expected improvement in the productivity of the industries has been explained by the fact that one of the major constraints was the unreliable supply of power. (CGEP, 2019; *Energy Projects Under CPEC | China-Pakistan Economic Corridor (CPEC) Secretariat Official Website*, n.d.)

Economic and Social Impacts of CPEC Energy Projects

Employment Data

The CPEC energy projects have resulted in the creation of many job vacancies, which are not only during construction but now as well. Independent calculations show that these projects have provided more than 303,000 of direct employment. In a roundabout manner, the improvement in energy reliability has encouraged the flow of economic activity, which in turn has created more job opportunities in different sectors. (CGEP, 2019)

Social Benefits

The remarkable positive social impacts of CPEC projects related to the energy sector in terms of improved energy access can be seen here too. They have recorded more health improvements because there is access to improved and reliable supplies of electricity most hospitals do not face power blackouts. These complement the education institutions' productivity as well, as reliable power supports a better learning environment. Also, the people in the rural regions of the developing countries have been favored with even more stable electricity supplies thus enhancing their quality of life. (CGEP, 2019; *Energy*

Projects Under CPEC | China-Pakistan Economic Corridor (CPEC) Secretariat Official Website, n.d.)

CONCLUSION

Altogether, the CPEC poses a new form of evolution in Pakistan's energy sector by presenting measurable solutions to power deficiencies and socioeconomic uplift. Based on the statistical analysis, it is evident that CPEC projects have been efficient in decreasing the energy unavailability and load-shedding occurrences in the country which acts as an essential source of aid to industries as well as households across the nation. The use of case studies like the Sahiwal Coal Power Plant displays the potential of increased generation capacity in solving energy deficit problems and the growth of the economy. Furthermore, CPEC has provided over 303,000 direct employment opportunities which shows that CPEC has facilitated job creation for the people of the region. Notably, better energy supply has yielded social impacts such as improved health and schooling in institutions especially in developing nations, especially in the rural regions. In the next stages, the sustainability of CPEC projects, coupled with good governance practices, and sound policies will be crucial in exploiting the benefits of CPEC and the growth of Pakistan's future.

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